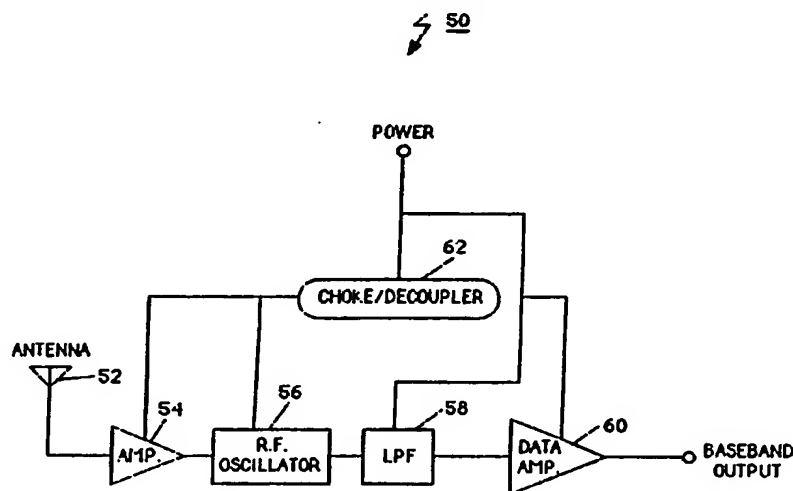


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## (54) Title: REMOTE CONTROL TRANSMITTER AND RECEIVER SYSTEM



## (57) Abstract

An improved remote control system adapted for use with consumer appliances and the like and having improved frequency stability and relatively low cost comprises a ceramic-stabilized r.f. hand-held remote transmitter unit operating in conjunction with a ceramic-stabilized r.f. receiver unit (50) located within the appliance to be remotely controlled. The hand-held transmitter unit includes a negative resistance oscillator which comprises a ceramic resonator and an associated active element and is linked through a suitable matching network to a loop antenna for broadcasting r.f. signals therefrom. Modulation of r.f. signals at the oscillator is accomplished by ON-OFF keying of a switch linked to the oscillator. The remote receiver unit (50) includes an antenna (52) for receiving the broadcast r.f. signals and an associated isolation amplifier (54) for improving signal spectrum radiation and increasing power gain. The remote receiver unit (50) is implemented in the form of a super-regenerative receiver using a self-quenched r.f. oscillator (56) in which the frequency reference is derived from a ceramic resonator tuned to the reference frequency in the transmitter unit.

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**REMOTE CONTROL TRANSMITTER  
AND RECEIVER SYSTEM****BACKGROUND OF THE INVENTION****Field of the Invention**

5           The present invention generally relates to remote control systems for consumer appliances and the like. More particularly, this invention relates to remote control systems wherein remote control of appliances, power equipment, etc. is effectively accomplished with the use of radio frequency (r.f.) signals.

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**Description of the Related Art**

15           Consumer and business applications requiring remote control of electrical/electronics appliances, power equipment and the like have proliferated in recent years. In particular, the remote control of business and home appliances such as televisions, audio/video equipment and the like using hand-held controllers has become increasingly popular and a virtual necessity under present day consumer market conditions.

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25           Remote control systems adapted for use with consumer appliances, most commonly television receivers, were initially based on the use of an ultrasonic beam as the carrier for transmitting information from a hand-held remote controller or transmitter to an associated receiver located within the appliance or T.V. set. Such ultrasonic remote control is particularly sensitive and susceptible to disturbance because spurious ultrasonic signals can easily be generated from a variety of sources, such as movement of objects and persons, in the vicinity of the remote control system.

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At the present time, remote control of T.V. sets and like

appliances is commonly accomplished by the use of infra-red energy as the carrier for transmission of control information from the remote controller to the receiver. The remote controller unit in these systems typically includes a signal generating section which converts various control signals for controlling a plurality of functions of a T.V. set, such as on/off switching, channel selection, color, brilliance and volume control, into a composite signal. The remote controller includes an infra-red transmitter for modulating the composite control signal on an infra-red carrier and relaying the resultant infra-red signal therefrom. The T.V. set being controlled remotely is provided with a receiver unit which includes a light- sensitive element and receives the composite control signal from the remote controller. The composite signal is subsequently decoded to effectuate the desired remote functions on the controlled T.V. set.

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The above-noted techniques of remote control using infra-red or ultrasound carriers are disadvantageous in several aspects, the most significant being their line-of-sight limitation with respect to the range of control. Both ultrasound and infra-red signals experience signal interruption and degradation in the presence of physical obstructions such as objects, walls, and persons, which are in the line of sight between the remote controller unit and the receiver on the controlled appliance.

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With infra-red remote controllers, for instance, it is critical that the light transmitting element on the unit be aimed in the general direction of the light receiving element on the receiver. Any obstruction between the controller and the receiver results in total signal disruption and, accordingly, loss of remote control capability. Thus, the use of infra-red remote controllers entails severely restricted range of control and freedom of use. In addition, ultrasound and infra-red systems are susceptible to interference from "noise" or spurious

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signals generated by background sound and light.

5 In recent years, radio frequency (r.f.) signals have been used in certain remote control applications with a view toward overcoming the above problems. The principal advantage with r.f.-based remote controllers is that physical obstructions such as those presented by persons, walls and other objects are transparent to r.f. signals. Accordingly, the range of remote control is substantially expanded beyond the generally enclosed area where the remote receiver is located  
10 to the maximum range within which the receiver is responsive to r.f. energy emitted from the remote controller transmitter.

15 However, conventional approaches to r.f. remote control systems typically involve elaborate circuit designs and system complexity, along with the attendant increase in cost and reduction in reliability. With particular reference to remote controllers of the hand-held type for use with commercial appliances such as T.V. sets and the like, existing r.f. remote systems generally use expensive surface acoustic wave (SAW) devices or conventional L-C type components (which are generally  
20 unreliable in long-term use) as frequency references at the transmitter and receiver ends, thereby adding significantly to the overall system costs and reducing system reliability significantly. Further, such remote control systems exhibit reduced sensitivity and, more importantly, the fundamental frequency of transmission in such hand-held systems is very  
25 susceptible to external effects such as the field effects resulting from a user's hand, moisture, etc.

30 Accordingly, there exists a need for an improved remote control system which is not subject to the above-discussed disadvantages associated with conventional ultrasonic, infra-red or r.f. remote control systems.

**SUMMARY OF THE INVENTION**

5 It is a principal object of the present invention to provide an improved remote control system which is adapted for use with hand-held controllers and has an extended range of operation.

10 A related object is to provide such an improved remote control system which has reduced susceptibility to interference from spurious signals.

An important object of the present invention is to provide an R.F.-based hand-held remote control system which has increased operational range and frequency stability.

15 An associated object is to provide such an R.F.-based hand-held remote system which has reduced susceptibility to external field effects.

20 A further object is to provide an R.F.-based remote control system of the above type which can be fabricated at low cost and has increased long-term reliability.

25 Briefly, in accordance with the principles of the present invention, the above and other related objects are realized by means of a remote control system comprising a ceramic-stabilized r.f. hand-held remote control transmitter unit operating in conjunction with a ceramic-stabilized r.f. receiver unit located within the appliance which is to be remotely controlled. The hand-held remote transmitter includes a negative resistance oscillator which comprises a ceramic resonator and an associated active element and is linked through a suitable matching network to a loop antenna. The oscillator action is modulated by ON-OFF keying of a switch which is linked to the oscillator.

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The remote receiver unit includes an antenna for the reception of r.f. signals broadcast from the remote transmitter and an associated isolation amplifier for improving the signal spectrum radiated to free space through the antenna and for improving sensitivity by providing the necessary power gain. The remote receiver unit is preferably implemented in the form of a super-regenerative receiver using a self-quenched r.f. oscillator in order to ensure circuit simplicity and high power gain. The problems of frequency drift and excessive bandwidth associated with the use of L-C components or SAW devices in conventional super-regenerative receivers are avoided by the use of a ceramic resonator element in the self-quenched r.f. oscillator used with the super-regenerative receiver.

The receiver unit includes a low pass filter for filtering out the quenched signals and the r.f. oscillating frequency while allowing the demodulated baseband signal to pass through. Amplification of the filtered signal is accomplished by means of a multi-stage cascaded data amplifier which is biased at a low level for increasing receiver sensitivity. The remote receiver is provided with a r.f. choke/decoupler unit for preventing the r.f. signal from backing into the power supply line.

The use of ceramic resonators for establishing the frequency reference in both the transmitter and the receiver units of the remote control system of this invention realizes increased frequency stability and receiver sensitivity without the excessive cost associated with the use of SAW devices or the long-term unreliability inherent to the use of conventional L-C type components. The range of control of the remote transmitter unit is substantially larger than that of conventional infra-red or ultrasonic remote controllers. Further, the transmitter unit is highly insensitive to load-pull effects so that the fundamental frequency of transmission is relatively independent of external effects acting on the

antenna, such as the fields generated<sup>6</sup> by the positioning of a user's hand in the vicinity of the transmitter antenna.

#### **Brief Description of the Drawings**

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Other objects and advantages of the present invention will become apparent upon reading the following detailed description and upon reference to the drawings in which:

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FIG. 1 is a schematic block diagram of an r.f. remote control receiver according to the system of this invention;

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FIG. 2 is a detailed schematic diagram of the r.f. remote control receiver of FIG. 1, in accordance with a preferred embodiment of the present invention;

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FIG. 3 is a block diagram of an r.f. remote control transmitter for use with the receiver of FIGS. 1 and 2; and

FIG. 4 is a detailed schematic diagram of the r.f. remote control transmitter illustrated in FIG. 3.

#### **Description Of The Preferred Embodiments**

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While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and will be described in detail herein. It should be understood, however, that it is not intended to limit the invention to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the

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appended claims.



Referring now to FIG. 1, there is shown a schematic block diagram illustrating the r.f. remote control receiver in accordance with the system of this invention. As shown therein, the receiver 50 is implemented in the form of a super-regenerative receiver including an antenna 52 for the reception of r.f. signals broadcast from an associated r.f. transmitter unit (to be discussed in detail below). The received r.f. signals are relayed from the antenna 52 to an isolation amplifier 54 which essentially functions to improve the signal spectrum radiated to free space through the antenna. In addition, the isolation amplifier 54 provides the power gain (typically 10 dB) required to realize improved receiver sensitivity.

The receiver 50 includes an r.f. oscillator 56 which, according to standard principles of super-regenerative reception, is operated at or close to the desired receiver center frequency and is alternated between an oscillating condition and a non-oscillating condition at a low radio frequency rate known as the quench frequency. Super-regenerative receivers or detectors of this type are commonly used at very high and ultra high frequencies because of various inherent advantages over conventional receivers using regenerative amplification. With regenerative amplification, the amplification effect is restricted to the point to where oscillations begin; no further amplification can occur beyond the point of oscillations. In super-regenerative receivers, this restriction on amplification is overcome by the process of quenching, whereby an alternating voltage with a frequency typically between 25 and 250 KHz is introduced into the receiver to realize a blocking action similar to that occurring in the operation of blocking oscillators.

The principal effect of the quenching process is to vary the operating point of the transistor detector used in the receiver so that the detector oscillates only during time periods when the varying operating point falls within the region where oscillations occur. As a

result, signal regeneration can be greatly<sup>8</sup> increased because of the constant interruption of the oscillations. The net result of the super-regenerative procedure is that the amplified signal is built up to a substantially large value. Accordingly, in such super-regenerative receivers, the degree of overall signal amplification is directly proportional to the difference between the quench frequency and the signal frequency. Thus, signal amplification is increased when this difference is increased because the signal has more time to build up during the half cycle when the quench signal is absent.

Returning to the receiver circuit of FIG. 1, the amplified r.f. signal from the isolation amplifier 54 is applied to the input of an active device (to be described in detail below) in the r.f. oscillator 56. The amplitude of the applied signal directly affects the time taken by the oscillator to reach its equilibrium amplitude. More specifically, the larger the amplitude of the applied signal, the sooner the oscillator 56 reaches its equilibrium amplitude. In effect, the applied signal increases or decreases the average area under the envelope of the quenched signal that is occupied by the r.f. oscillations according to the level of the applied signal.

The receiver 50 of FIG. 1 includes a low pass filter 58 for obtaining the demodulated signal from the output of the oscillator 56 by low pass filtering thereof so as to reject the r.f. and quench frequencies. As is well understood in the art of super-regenerative reception, the quench frequency is essentially a sampling signal that samples the signal to be demodulated and, thus, the quench frequency must always be greater (ideally at least ten times greater) than the frequency of the demodulated signals.

The filtered signal from filter 58 is subsequently processed by a data amplifier 60 which is preferably a multi-stage cascaded amplifier

realizing the required degree of signal gain. The output of data amplifier 60 then becomes available as the baseband output for the remote control system. The receiver circuit of FIG. 1 is also provided with a r.f. choke/decoupler unit 62 which essentially functions to prevent the feeding of any portion of the r.f. signal back to the power line over which operational power is supplied from a central power source to both the isolation amplifier 54 and the r.f. oscillator 56. As also shown in FIG. 1, the same power source is used to supply power to the low pass filter 58 and the data amplifier 60.

10

Referring now to FIG. 2, there is shown a detailed schematic diagram of a remote receiver unit in accordance with a preferred embodiment of this invention. As shown therein, the antenna 52 of the receiver unit captures radiated r.f. signals and relays them onto a isolation amplifier comprising an NPN transistor  $T_1$  which is operated in a common emitter configuration and is powered from a DC power supply (typically, 12 VDC) through a resistance R2 connected to its collector. The r.f. signals are fed to the base of the transistor  $T_1$  through a capacitor C1. A feedback path is established between the base and the collector of the transistor  $T_1$  by means of a resistor R1. An isolation capacitor C2 is used to extract the amplified output of the amplifier for being supplied to subsequent sections of the receiver circuitry.

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The isolation amplifier essentially functions to improve the spectrum of r.f. signals radiated to free space through the antenna 52 and basically isolates the sensitive regenerative circuit of the receiver from the antenna 52 and its associated VSWR problems. Preferably, the components comprising the isolation amplifier are selected to be such that the amplifier realizes a gain of about 10 decibels and a rejection factor of about 20 decibels.

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The amplified output from the capacitor C2 is fed to an r.f. oscillator operating in the self-quench mode whereby the quench signal for the oscillator is generated using the common emitter amplifier used for isolation and amplification of the captured r.f. signals. The self-quench r.f. oscillator includes as its active element an NPN transistor  $T_2$  which receives the amplified signals at its collector. Power to the oscillator is supplied to the base of the transistor  $T_2$  through a pair of parallel-connected resistors R3 and R4, with resistor R4 being directly tied into the base of transistor  $T_2$  and the resistor R3 being linked thereto through a capacitor C4. The common junction of the resistor R4 and the base of transistor  $T_2$  is connected to ground through a resistor R5.

The above arrangement essentially constitutes a negative resistance oscillator having a time constant which determines the quench frequency of the circuit. This time constant is defined by the component values of a capacitor C7 connected on one end to the base of transistor  $T_2$  and on the other to a resistor R6 which, in turn, is connected to ground. The junction of the capacitor C7 and the resistor R6 is connected to the emitter of transistor  $T_2$  through an inductance L2. Accordingly, the time constant of the oscillator circuit is determined by the product of the component values for the resistor R6 and the capacitor C1. The inductor L1 essentially provides a high impedance to the emitter of transistor  $T_2$ .

In conventional super-regenerative receiver circuits, the r.f. oscillator has its frequency of oscillations rendered controllable by the provision of L-C components which generally degrade the overall performance of the remote receiver unit as well as the associated remote transmitter unit. More specifically, these components contribute to substantial center frequency drift due to temperature excursions or aging of circuit components and also realize excessive bandwidth which,

in turn, decreases receiver sensitivity and increases susceptibility to interference from other signal sources.

More recently, improved operation of regenerative receivers of this type has been accomplished by the use of surface acoustic wave (SAW) devices as frequency references. While SAW devices exhibit high frequency stability and provide the receiver with high sensitivity, the extremely narrow capture bandwidth (of the order of less than 1 MHz) of such devices requires that the transmitter unit used for broadcasting the requisite r.f. signals be highly stable. The maintenance of extremely tight tolerances on the fundamental frequency of transmission makes the transmitter circuit complex and extremely costly.

More importantly, however, SAW devices are inherently extremely expensive and become impractical in most hand-held remote control applications where it is imperative that the transmitter units be designed to display circuit simplicity and reduced manufacturing costs. Further, in most hand-held remote control applications involving consumer appliances, the bandwidth of the emitted spectrum is of the order of about 2-5 MHz and, accordingly, not particularly suited for use with SAW devices and conventional L-C type components (having a capture bandwidth extending to 40 MHz).

In accordance with a feature of the present invention, the above problems are avoided by means of an oscillator circuit design wherein the frequency of oscillation is determined by a ceramic resonator CR1 which is connected to the output point of the isolation amplifier between the capacitor C2 and the junction of the resistor R3 and the capacitor C4. A capacitor C3 links the ceramic resonator CR1 to ground.

The use of the ceramic resonator CR1 provides distinct

advantages over conventional frequency reference approaches.

Primarily, the resonator has a substantially lower cost than conventionally used SAW devices. More importantly, the resonator has substantially increased frequency stability and maintains its electric field confined within its outer ceramic coating. This factor is particularly important in hand-held devices where the presence of a user's hand and associated hand moisture in the vicinity of the transmitter unit antenna can substantially affect the operational frequency thereof. Thus, using a ceramic resonator as the frequency reference in both the transmitter (as will be described in detail below) and the receiver (as described in connection with FIG. 2) substantially eliminates frequency drift and, at the same time, restricts the capture bandwidth sufficiently.

Returning now to FIG. 2, the output of the self-quenched r.f. oscillator is processed by a low pass filter which essentially functions to filter out the quenched signal and the r.f. oscillating frequency while allowing the demodulated baseband signal to pass through. In the arrangement of FIG. 2, the baseband signal is directed to a data amplifier consisting of two cascaded stages which are capacitively coupled together. More specifically, the baseband signal is fed through a serial connection of resistor R7 and a capacitor C9 to the base of an NPN transistor T<sub>3</sub> which is operated in a common emitter configuration with the emitter connected directly to ground. The base of the transistor T<sub>3</sub> is also connected to ground through a capacitor C10 and linked through a feedback path formed by resistor R8 to the emitter of the transistor.

The first amplifier stage is supplied with power from the 12 VDC receiver power supply through a resistor R9 connected to the collector of transistor T<sub>3</sub>. The amplified output of the first amplifier stage is taken from the collector of transistor T<sub>3</sub> and supplied through a capacitor C12 to the base of a transistor T<sub>4</sub> included in the second

amplification stage. A bypass capacitor C11 connects the junction of<sup>13</sup>  
the collector of transistor T<sub>3</sub> and capacitor C12 to ground. The base of  
transistor T<sub>4</sub> is supplied with power from the 12 VDC power supply  
through a resistor R10 and is also linked to ground through a resistor R11.

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The power supply point of the receiver is also connected to the  
collector of transistor T<sub>4</sub> through a resistor R12 and the emitter of the  
transistor is linked to ground through a resistor R13. The amplified  
output from the second amplification stage is extracted from the  
collector of the transistor T<sub>4</sub> through a load resistor R14, the output end  
of which is linked to ground through a bypass capacitor C13.  
Accordingly, the junction of resistor R14 and the capacitor C13  
constitutes the point at which the amplified demodulated baseband  
signal becomes available.

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Preferably, the first amplification stage is biased at approximately  
half of the supply voltage and acts as a standard AC amplifier, while the  
second cascaded stage basically operates as a DC switch. Preferably,  
the baseband signal is utilized in a digital form and the amplifier circuit  
is biased at a low level (about 0.6 volts) in order to increase receiver  
sensitivity.

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The receiver arrangement of FIG. 2 also includes an r.f.  
choke/decoupler unit disposed between the power supply source and  
the isolation amplifier and the self-quenched r.f. oscillator. The  
choke/decoupler circuit is essentially a low pass filter comprising an r.f.  
choke L1 disposed between a pair of grounded capacitors C5 and C6  
which function as decoupling capacitors. As described below, the r.f.  
choke/decoupler essentially functions to prevent r.f. signals being fed  
back to the power source. In essence, the circuit permits unrestricted  
passage of DC signals from the power source but provide a high degree  
of frequency rejection in the reverse direction.

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Referring now to FIG. 3, there is shown a block diagram of a remote transmitter unit according to the present invention. As shown therein, the transmitter unit essentially comprises an oscillator 12 which (as will be described below) uses a ceramic resonator similar to that used in the receiver unit of FIG. 2 as a frequency reference element. The oscillator 12 functions to generate the required r.f. signals at the desired fundamental frequency of transmission. The output of the oscillator 12 is connected through an appropriate matching network 14 to a loop antenna 16, from where demodulated r.f. signals may be radiated outwardly for reception by the receiver antenna. The impedance of the loop antenna is usually small and the matching network 14 functions to transform this impedance to a higher impedance, such as the 50 ohm impedance commonly used in such circuits. The r.f. antennas in both the transmitter unit and the receiver unit are preferably implemented in the form of integral printed antennas on the printed circuit board on which the units are generally defined.

The required modulation of the oscillator 12 is realized by a switch 18 which is supplied with power from an appropriate power source, such as a battery. Preferably, the transmitter is operated in a pulse phase modulation (PPM) mode and the oscillator 12 is modulated by the ON-OFF keying of the switch 18 which is accomplished by some form of active element, preferably, a transistor. This type of modulation technique is well known in the art and, accordingly, is not discussed in detail herein.

Referring now to FIG. 4, there is shown a detailed circuit schematic in accordance with a preferred implementation of a transmitter unit according to this invention. As shown therein, the transmitter unit has a negative resistance oscillator which comprises a ceramic resonator CR2 acting in conjunction with an active element,



such as a transistor  $T_1$ . It will be obvious that the ceramic resonators in both the receiver and the transmitter units can conveniently be tuned to the same frequency for synchronization of the transmit and receive operations. One end of the resonator CR2 is grounded while the other is connected through a coupling capacitance C29 to the base of the transistor  $T_1$ . The power supply point for the oscillator is defined by the point where a resistor R25 is connected to the collector of transistor  $T_1$ . The other end of resistor R25 is linked to ground through a resistor R24 and to the base of the transistor  $T_1$ . The emitter of the transistor  $T_1$  is linked to ground through a resistor R23 and is also connected to the base of the transistor through a coupling capacitor C28.

The requisite modulation of the oscillator is accomplished by means of a switch defined by an active element such as an NPN transistor  $T_2$  which receives the power supply  $V_{cc}$  (typically, 9 VDC) at its emitter and has its base connected to a biasing voltage  $V_b$  through a resistor R2. A pair of isolation capacitors C21 and C22 are connected in parallel across the power supply line and ground. A bias resistor R21 connects the base of the transistor  $T_2$  to its emitter. The switched output generated by this transistor switch is extracted at the collector of the transistor  $T_2$  and linked to the power supply point for the negative resistance oscillator, i.e., to the collector of transistor  $T_1$ . An isolation capacitor C27 links this supply point to ground.

The modulated oscillator output is extracted at the collector of transistor  $T_1$  of the oscillator and is connected through a capacitor C23 to one end of a loop antenna Z1, the other end of which is connected through a capacitor C25 to the emitter of the oscillator transistor  $T_1$ . A pair of decoupling capacitors C24 and C26 are connected across the antenna feed points on either side of the capacitor C25. The capacitors C23 and C24 define the matching network which functions to transform the typically low impedance of the loop antenna to the higher

impedance (typically 50 ohms) associated with such transmitter circuits. More specifically, the capacitor C23 functions to provide the necessary resonance with the antenna loop and the capacitor C24 provides the necessary impedance transformation to the higher impedance level.

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In the circuit arrangement of FIG. 4, the combination of the ceramic resonator CR2 and the circuit associated with the transistor T<sub>1</sub> constitutes a negative resistance oscillator which has a low output resistance since the oscillator output is derived from the emitter of the oscillator active element. In addition, the isolation capacitor C26 is selected to have a sufficiently low value (typically 1 pf) that good isolation is realized between the oscillator and the load associated therewith, i.e., the loop antenna Z1. Preferably, the bandwidth of the loop antenna is selected to be narrow (typically about 3.8 MHz for a VSWR value of 2.0) and the dimensions of the loop antenna are selected to be such that the efficiency and the loop area is optimized. Preferably, the transmitter of FIG. 4 is operated in the PPM mode and the negative resistance oscillator is modulated by the ON-OFF keying of the transistor switch as accomplished by the action of the transistor T<sub>2</sub>.

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A remote control system comprising a hand-held transmitter unit and receiver unit as described above was fabricated and satisfactorily tested in accordance with the following component values, which are listed below for the purpose of illustration only, without any intention of restriction thereto.

25

	<u>Component</u>	<u>Value</u>
	R1	100 K
30	R2	1 K
	R3	8.2 K
	R4	33 K
	R5	4.7 K
	R6	1 K
35	R7	33 K

		17	
	R8		2.2 M
	R9		18 K
	R10		120 K
5	R11		5.6 K
	R12		8.2 K
	R13		220 $\Omega$
	R14		33 K
	R21		33 K
	R22		33 K
10	R23		820 $\Omega$
	R24		8 K2
	R25		5 K6
	C1		100 P
15	C2		1 P
	C3		1000 P
	C4		3 P (N 750)
	C5		1000 P
	C6		4.7 $\mu$
20	C7		1000 P
	C8		10 P
	C9		.33 $\mu$
	C10		4700 P
	C11		4700 P
25	C12		.33 $\mu$
	C13		1000 P
	C21		100 P
	C22		.1 $\mu$
	C23		5 P
30	C24		47 P
	C25		1 P
	C26		1 P
	C27		100 P
	C28		20 P
35	C29		4 P (N 750)

40 With the above arrangement, the operational frequency of the remote control system is 430 MHz and the center frequency of the transmitted and received r.f. signals is defined at 383.99 MHz. The impedance of the loop antenna in the transmitter is such that, at the center frequency of 383.99 MHz, a bandwidth of about 3.8 MHz results at a VSWR equal to two (2.0). The receiver signal spectrum is, of

course, centered at the 383.99 MHz frequency and has a -10 dB .  
bandwidth of about 4 MHz. The arrangement realizes a receiver  
sensitivity of about -85 dBm and a spurious emission level of about -78  
dBm with a load of 50  $\Omega$ .

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It will be apparent from the foregoing that the present invention  
provides a remote control system having low cost, increased frequency  
stability and high receiver sensitivity because of the use of ceramic  
resonators for establishing the frequency reference in both the  
10 transmitter and the receiver units. The transmitter unit has increased  
range of control and is highly insensitive to load-pull effects making the  
fundamental frequency of transmission relatively independent of  
external effects on the antenna.

Claims

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1. A remote control system comprising:
  - 2 a hand-held unit including a transmitter having a DC power supply, an oscillator circuit with a ceramic resonator for generating a radio-frequency (r.f.) signal when connected to said power supply, and an antenna for radiating said r.f. signal; and
  - 6 a receiver for receiving and detecting the radiated radio-frequency signal, said receiver including an antenna for receiving said r.f. signal, a DC power supply, and an oscillator circuit with a ceramic resonator for detecting signals having the same frequency generated by the oscillator circuit in said transmitter.
2. The remote control system according to claim 1 wherein said antenna in said transmitter is a loop antenna.
3. The remote control system according to claim 2 wherein said loop antenna in said transmitter has a low impedance and said oscillator circuit has a relatively higher impedance, and said antenna is connected to said oscillator through an impedance matching network for transforming the low impedance of said loop antenna to the high impedance of said oscillator.
4. The remote control system according to claim 1 wherein said oscillator in said transmitter is associated with an active switch for modulating said r.f. signal generated by said oscillator.
5. The remote control system according to claim 1 wherein said receiver includes an amplifier for amplifying the received r.f. signal and isolating said amplified r.f. signal from said antenna.
6. The remote control system according to claim 5 wherein

2 said oscillator in said receiver is a negative resistance oscillator whose  
fundamental frequency of oscillation is defined by said resonator, said  
resonator also having an operational bandwidth corresponding to the  
4 bandwidth of said receiver r.f. signal.

7. The remote control system according to claim 6 wherein  
2 the receiver includes a low pass filter for processing the output of said  
oscillator circuit.

8. The remote control system according to claim 1 wherein  
2 said receiver further includes an amplifier comprising first and second  
capacitively coupled cascaded stages for amplifying the detected r.f.  
4 signal.

9. The remote control system according to claim 6 wherein  
2 said receiver further includes a low pass filter including an r.f. choke  
and at least two decoupling capacitors for isolating r.f. signals from said  
4 receiver amplifier and said receiver oscillator from said power supply.

10. A hand-held remote control transmitter unit adapted for  
2 use with an r.f.-based remote control system, said transmitter unit  
comprising:  
4 a negative resistance oscillator including a ceramic resonator for  
defining the fundamental frequency of oscillations of said oscillator, said  
6 oscillator adapted to generate modulated r.f. signals; and  
an antenna for radiating said r.f. signals outwardly therefrom.

11. The hand-held transmitter unit according to claim 10  
2 wherein said antenna is a loop antenna.

12. The hand-held transmitter unit according to claim 11  
2 wherein said loop antenna in said transmitter has a low impedance and

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..2 said oscillator has a relatively higher impedance, and said antenna is  
connected to said oscillator through an impedance matching network for  
transforming the low impedance of said loop antenna to the high  
4 impedance of said oscillator.

13. The hand-held transmitter unit according to claim 12  
2 wherein said oscillator in said transmitter is associated with an active  
switch for modulating said r.f. signal generated by said oscillator.

14. A remote receiver unit adapted for receiving r.f. signals  
2 transmitted from a hand-held, ceramic-stabilized remote transmitter  
unit, said receiver comprising:  
4 an antenna for receiving said r.f. signals; and  
an oscillator circuit including a ceramic resonator for detecting  
6 r.f. signals having the same frequency as the ceramic-stabilized r.f.  
signals from said transmitter unit.

15. The remote receiver according to claim 14 wherein said  
2 receiver includes an amplifier for amplifying the received r.f. signals and  
isolating said amplified r.f. signals from said antenna.

16. The remote receiver according to claim 15 wherein said  
2 oscillator in said receiver is a negative resistance oscillator whose  
fundamental frequency of oscillation is defined by said resonator, said  
4 resonator also having an operational bandwidth corresponding to the  
bandwidth of said receiver r.f. signals.

17. The remote receiver according to claim 16 wherein the  
2 receiver includes a low pass filter for processing the output of said  
oscillator.

18. The remote receiver according to claim 14 wherein said

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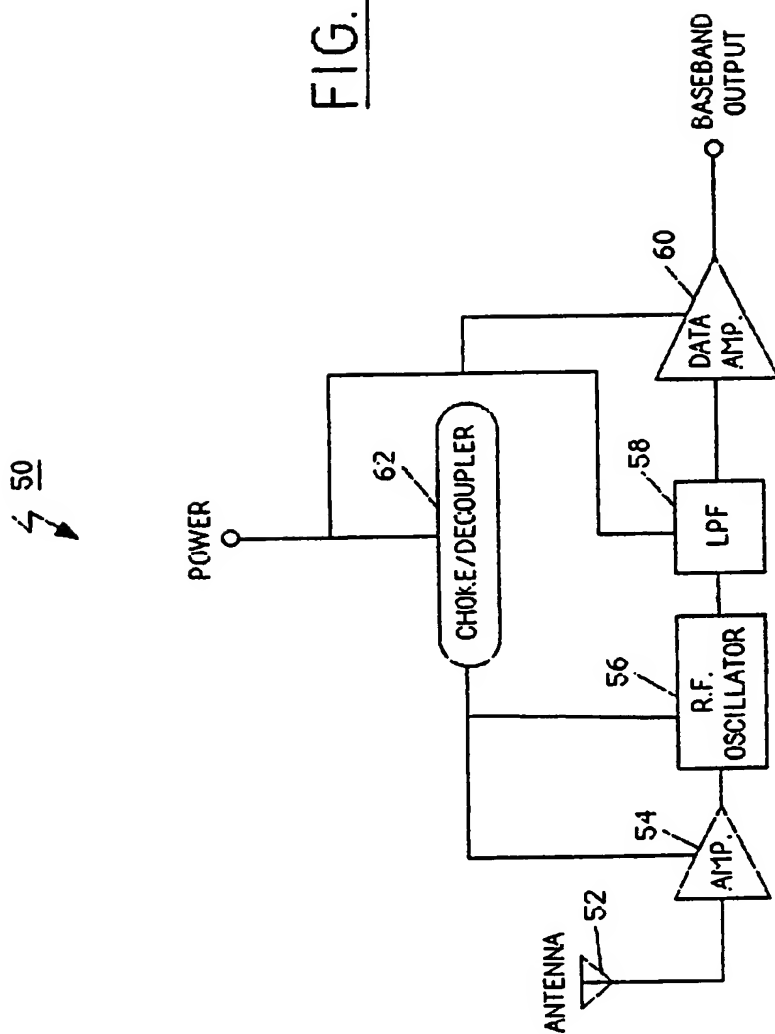
2 receiver further includes an amplifier comprising first and second .  
2 capacitively coupled cascaded stages for amplifying the detected r.f.  
signals.

19. The remote receiver according to claim 16 wherein said  
2 receiver further includes a low pass filter including an r.f. choke and at  
least two decoupling capacitors for isolating r.f. signals from said  
4 receiver amplifier and said receiver oscillator from said power supply.



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FIG. 1



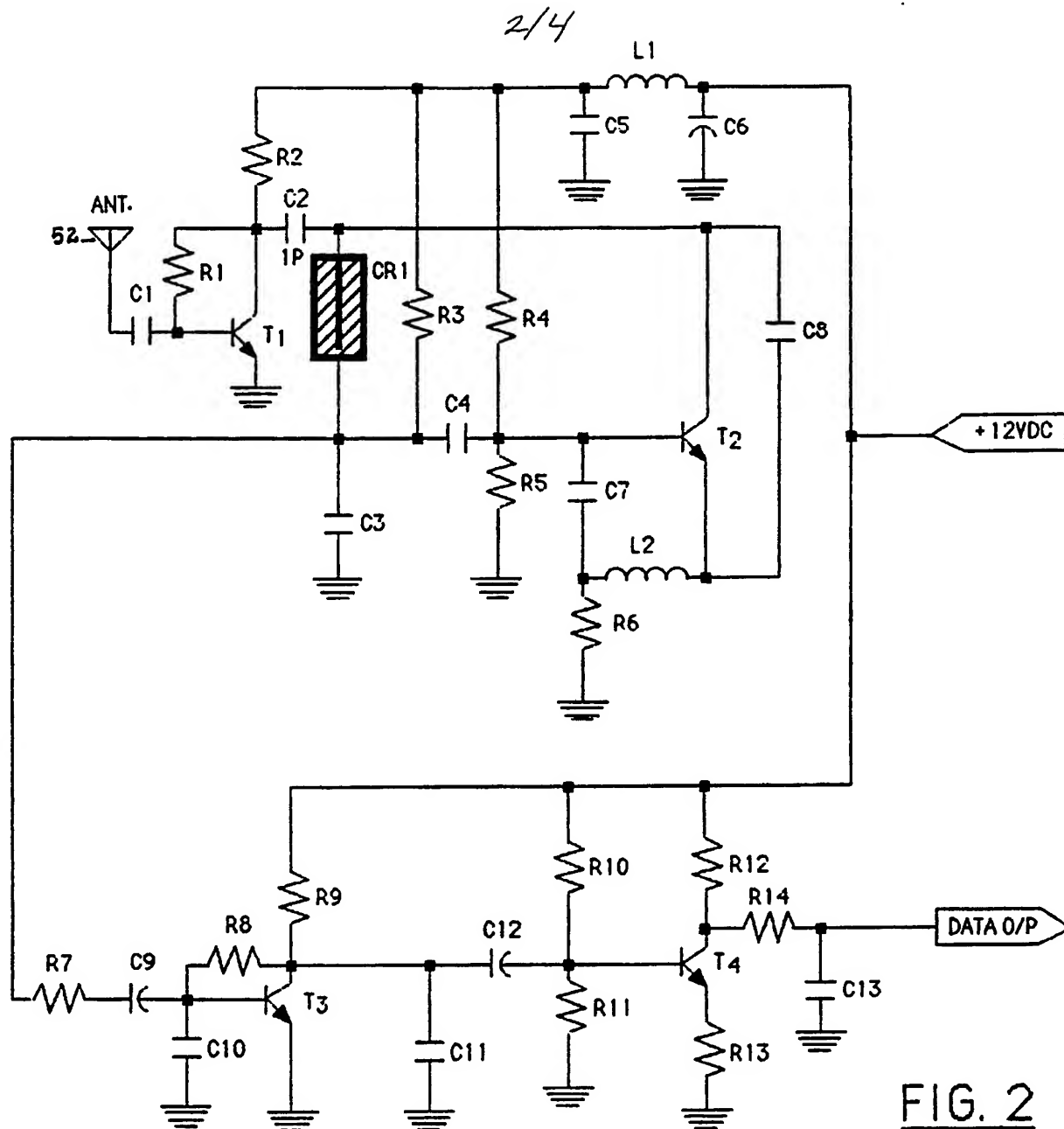


FIG. 2

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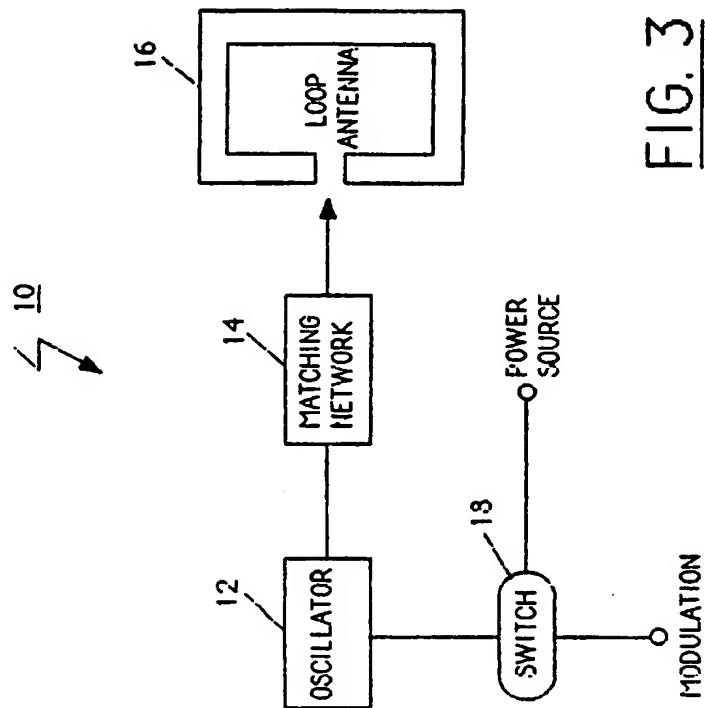
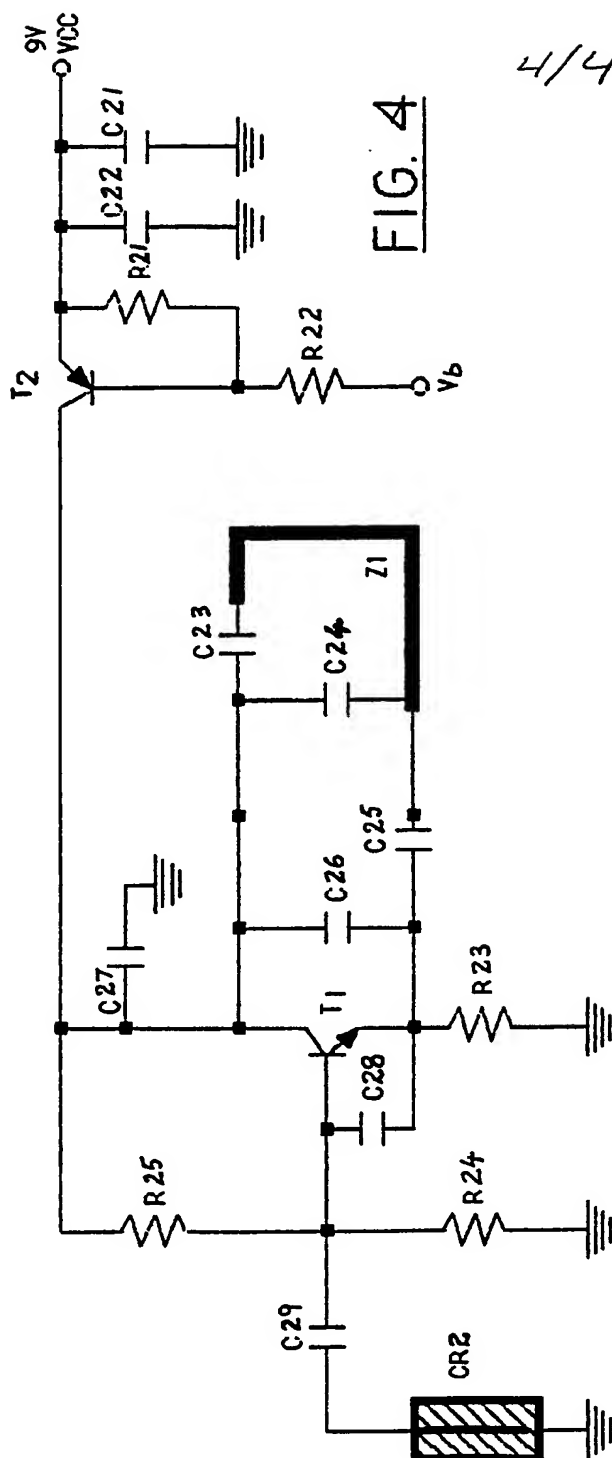


FIG. 3



# INTERNATIONAL SEARCH REPORT

International Application No. PCT/US91/06263

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) *		
According to International Patent Classification (IPC) or to both National Classification and IPC		
INT. CL(5): H04B 1/06		
US CL : 455/352		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
U.S.	455/352, 353, 355 358/194.1 340/825.64, 825.72	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched *		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT</b> *		
Category *	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
Y	US, A, 4,148,020 (SIEMER ET AL.) 03 APRIL 1979 See entire document.	1-19
Y	US, A, 4,475,123 (DUMBAULD ET AL.) 02 OCTOBER 1984 See entire document.	1-19
Y	US, A, 3,049,711 (HOOPER) 14 AUGUST 1962 See entire document.	2-3, 11-12
Y	US, A, 4,236,594 (RAMSPERGER) 02 DECEMBER 1980 See entire document.	1-19
Y	US, A, 4,871,997 (ADRIAENSSENS ET AL.) 03 OCTOBER 1989, See entire document.	1-19
Y	US, A, 4,672,365 (GEHMAN ET AL.) 09 JUNE 1987 See entire document.	1-19
<p>* Special categories of cited documents: <sup>10</sup></p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
05 DECEMBER 1991	18 DEC 1991	
International Searching Authority	Signature of Authorized Officer	
ISA/US	CHRIS BELZER	



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